

# **A FLYBACK TYPE ALTERNATION POWER SUPPLY WITH PRIMARY/SECONDARY SYNCHRONIZE CONTROL**

## **Field of the invention**

5        The present invention relates to a flyback type alternation power supply with primary/secondary synchronize control; specially relates to a power supply that turns on and off by using a switching component.

## **Background of the invention**

10        As shown in Fig. 1A: the circuit diagram of general flyback type alternation power supply. Wherein, the switching component S1 could be a transistor, thyristor or MOSFET that controls on/off function with small signals. The component D1 has uncertain voltage drop within 0.4~1.5V when it is conducting (characteristics of diode). Therefore, the events such as low  
15        efficiency or diode needing large area of heat dissipating fan due to over consumption of power when outputting voltage  $V_o$  is low. For example, when  $V_o$  is 5V dc, voltage drop of D1 is 0.4V with D1 reverse voltage 30V dc and outputting power of power supply is 50W(5V/10A); then the power consumption on D1 is  $0.4 * 10A = 4W$ . By neglecting power losses of other  
20        components, the efficiency of this power supply is  $50W / (50W + 4W) = 96\%$ .

      In other case as shown in Fig. 1B: the circuit diagram of a prior art flyback type alternation power supply. In order to rise the efficiency of flyback type alternation power supply, the D1 component is replaced with S2 (transistor, thyristor or MOSFET). With current technology on MOSFET, such as SI4410,

the RDS (on) can be lowered to 10 mΩ for reducing power consumption to overcome the above-mentioned drawback. If we use the above example for comparison and replacing Vo to 5V dc, S2 to SI4410 (RDS = 11 mΩ, V DS = 30V) and output power is 50W (5V/10A); then voltage drop across S2 is

5     $10A * 11 \text{ m}\Omega = 110 \text{ mV dc}$ . The power consumption of S2 is now  $110\text{mV} * 10A = 1100\text{mW} = 1.1 \text{ W}$ . Without including power consumption of other component, the efficiency is now  $50W / (50W + 1.1W) = 97.8$ , which is raised 6.2% in compare to use of diode. Although this is the goal of Engineers, but the process of replacing D1 to S2 still meets technical bottleneck.

10        The Fig. 2 shows the voltage and current waveform of flyback transformer in prior-art. S2 must be accurately controlled to conduct after occurrence of t1 and cut-off before arrives of t2. Generally speaking, t1a is easier to control because t1 is the time when VN2 switching from negative to positive. We could use VN2 as a trigger signal (after some set delay time) to conduct S2. However,

15    the occurrence of flyback transformer t2 changes along with the variation of load (I0) and it is difficult to predict. Further, t2a must cut-off S2 before arrival of t2; otherwise, Co will charge N2 through S2 and generate a reverse current (-IS1) when S1 is again conducted, which can result in damage of S1.

          Therefore, when flyback type alternation power supply uses the switching

20    component to control its secondary side rectification circuit (in transformer), normally the switching component in secondary side is used to control its conduct/cut-off state whereas the primary side is normally controlled passively. In other words, flyback type alternation power supply commands the switching component in secondary side to cut-off and then command the switching

component in primary side to conduct. For example, a current transformer detects secondary current on the instant it reaches zero point; the switching component at the secondary side is commanded to cut-off. Then the primary side switching component is conducted by using remain field of the transformer to produce electromotive force. However, this technology is usually applied on non-continuous mode (secondary switching component cut-off when secondary current reaches zero, and then conduct switching component on the primary side).

The previous described method on flyback type alternation power supply using switching component at the secondary side as active and switching component on the primary side as passive can only operate the power supply on non-continuous mode. The result is a larger volume of transformer and less efficiency of power supply. If we can make flyback type alternation power supply to function in continuous mode, then we have the advantages on smaller volume of transformer and higher efficiency of power supply. The continuous mode means that the switching component at the primary side is conducted while the current on the secondary side is still higher than zero point and enters cut-off mode.

Furthermore, the previously mentioned current transformer on detecting variation of secondary current could cancel the effect of using switching component instead of diode. Because current transformer blocks direct current and therefore circuits must be added to recover the DC level. This manner will largely affect the accuracy of current transformer when it is used to detect current level. The concern is that the accuracy of the current transformer is

vitaly important on detection; otherwise, the alternating power supply will either easily burned down or raise less possible efficiency.

Therefore, we can see from the above described prior-art on flyback type alternation power supply, which has some inconvenience and disadvantages on  
5 practical application that can be further improved.

### **Summary of the invention**

The main purpose of the present invention is to provide a primary/secondary synchronize control on flyback type alternation power  
10 supply, which relates to the prior-art of flyback type alternation power supply with using switching component to control transformer output. The switching component consumes very low power and hence it effectively raises the efficiency of the power supply. However, for the best performance of flyback type alternation power supply the switching component must be controlled  
15 accurately on the conduction and cut-off timing. There has been mentioned in the prior-art about how to effectively control the conduction time using switching component. Nevertheless, there are still many difficulties to overcome in controlling of cut-off time using switching component. Therefore, the present invention aims to provide a control to make power supply raises its  
20 efficiency with the use of switching component by controlling its cut-off time.

To achieve the above goal, the present invention further provides a flyback type alternation power supply with primary/secondary synchronize control, which consists of a transformer, a primary switching unit, a secondary switching unit, and a insulation unit. Wherein, the primary switching unit is

constituted by a first switching component and a first control circuit; the first switching component connects to the primary side of the transformer and its conduction state is controlled by the first control circuit. Further, the secondary switching unit consists at least a second switching component, which connects  
5 to the secondary side of transformer. The mentioned insulation unit is connected in between the first control circuit and the second switching component, wherein the first control circuit controls the insulation unit for outputting a cut-off signal to command the second switching component to enter the cut-off state.

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15 switching component connects to the primary side of the transformer and its conduction state is controlled by the first control circuit. Further, the secondary switching unit consists at least a second switching component, which connects to the secondary side of transformer, and a second control circuit, which controls the conduction state of the second switching component. The  
20 mentioned insulation unit connects in between the first control circuit and the second control circuit; wherein the first control circuit controls the insulation unit for outputting a cut-off signal to the second control circuit, which then command the second switching component to enter a cut-off state.

Additional objects and advantages of the invention will be set forth in

description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

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### **Brief description of the drawings**

Fig. 1A: the circuit diagram of general flyback type alternation power supply;

Fig. 1B: the circuit diagram of present flyback type alternation power supply;

10 Fig. 2: the voltage and current waveforms of the Fig. 1B;

Fig. 3: the block circuit diagram of the first preferred embodiment in the present invention;

Fig. 4: the circuit diagram of the second preferred embodiment in the present invention;

15 Fig. 5: the waveforms of the Fig. 4;

Fig. 6: the circuit diagram of third embodiment in the present invention;

Fig. 7: the waveforms of the Fig. 6.

### **Detail descriptions of the preferred embodiments**

20 Please refer to Fig.3 the block circuit diagram of the preferred embodiment in the present invention. The present invention is a flyback type alternation power supply with primary/secondary synchronize control, which consists of a transformer 1, a primary switching unit 2, a secondary switching unit 3 and an insulation unit 4. Wherein, the transformer 1 has a primary side 11 and a

secondary side 12. The primary switching unit 2 connects to the primary side 11 and secondary switching unit 3 is connected to secondary side 12. The duty of transformer 1 in the flyback type alternation power supply is mainly to transfer energy from primary side 11 to secondary side 12. There are  
5 positive/negative reverse voltages and its relative currents at the output ends of primary side 11 and secondary side 12.

The primary switching unit 2 is connected to an electric supply source  $V_{source}$  for generating high frequency signal  $V_{in}$  and primary electric current  $I_{in}$ . Wherein, the primary switching unit 2 is constituted by a first switching  
10 component 21, which is joined to primary side 11 of the transformer 1, and a first control circuit 22. The first control circuit 22 is used to control the conducting/cut-off states of the first switching component 21. In this way, the switching state operation of transformer 1 can be mastered. Moreover, the first switching component 21, which is controlled with small signals, is MOSFET  
15 (Metal Oxide Semi-conductor Field Effect Transistor) or thyrister.

The secondary switching unit 3 is formed by the connection of a second switching component 32 and primary side of transformer 12. The output capacitor  $C_o$  is connected to the output end of the second switching component 32 and outputting a voltage  $V_o$ . Wherein, the second switching component 32  
20 controls the output of secondary current  $I_D$  base on the switching state of transformer 1. Moreover, the second switching component 32, which is controlled by small signals, is MOSFET (Metal Oxide Semi-conductor Field Effect Transistor) or thyrister.

The insulating unit 4 is connected to first control circuit 22 and second

switching component 32. It is used to output a cut-off signal to the second switching component 32 for entering cut-off state.

The main operating principle in this preferred embodiment of the present invention will now be described in the following article. Firstly, assume the  
5 first switching component 21 at the primary side 11 is in cut-off state and the second switching component 32 at the secondary side 12 is in a conducting state. At this time, the secondary current  $ID1$  has a reverse triangular wave pattern, which depicts the gradual changes of secondary current  $ID1$  from large to small. Although one of the main functions of the first control circuit 22 is to  
10 control the conducting time of the first switching component 21. However, the most important duty is actually to send out a cut-off signal to the second switching component 32 via insulating unit 4 before first switching component 21 conducts. In this way, at the time when transformer 1 has switching state variation after first switching component 21 has conducted, the drawback  
15 situation of simultaneous conduction of both primary and secondary switching components can be avoided. Further, the first control circuit 22 could control time of sending cut-off signal to second switching component 32 and make second switching component 32 to enter cut-off state before or at the time secondary current  $ID1$  descends to zero. Hence, it allows this preferred  
20 embodiment of the present invention can be able to operate in continuous or non-continuous mode. Wherein, the length of conduction time of the first switching component 21 is also controlled by first control circuit 22. When first switching component 21 cut-off, the transformer changes its switching state and secondary will again shows the above mentioned reversed triangular wave

pattern.

Please refer to Fig.4: the circuit diagram of the second preferred embodiment in the present invention. Wherein, the first switching component 21 is P type MOSFET (Metal Oxide Semi-conductor Field Effect Transistor)

5 Q6. The first control circuit 22 consists of a plus-width modulation control IC (number 3843 or 3842) U1, capacitors (C1, C2, CT), resistors (R5, R6, RT), and transistors (Q7, Q8). The insulating unit 4 is constituted by transformer T2, resistor R4, diode D4 and transistor Q5. Moreover, the second switching component 32 is N type MOSFET (Metal Oxide Semi-conductor Field Effect

10 Transistor) Q1. One important feature, which is added to this preferred embodiment, is the second control circuit 31 for controlling cut-off state of the second switching component 32 and receiving cut-off signal from insulating unit 4.

The above-mentioned second control circuit 31 is constituted by a voltage

15 level/divider circuit 311, driver circuit 312 and buffer circuit 313. Wherein, the voltage level/divider circuit 311 provides a voltage preference level; buffer circuit 313 outputs a voltage for controlling resistance variation in second switching component. The driver circuit 312 adjusts the output voltage of buffer circuit 313 bases on voltage preference level and enables a voltage-drop

20 that is generated by a current flowing through the second switching component 32 to remain at a fix value. Further, the driver circuit 312 also allows resistance of second switching component 32 could vary inversely proportionally along with the output current from the transformer 1.

The operating principle of second control circuit 31 will now be described

first. In the control circuit 31, the secondary current  $ID1$  is assumed in reverse triangular wave-shape pattern and diode  $D1$ ,  $D2$  and  $D3$  provides current insulation effect. For convenience of description, the voltage-drop across diode  $D1$ ,  $D2$  and  $D3$  are neglected in the following article. Some assumptions are also made; such as suppose conducting resistance of  $Q1$  is  $15\text{ m}\Omega$ ,  $V_{be}$  voltage of  $Q4$  is  $0.6\text{V}$ ,  $V3$  is set to  $6.15\text{V}$ .

Wherein, another circuit, which is in parallel connection with  $V3$  point, is the serial connection of b-e in  $Q4$  and s-d in  $Q1$ . Therefore, the voltage-drop on S-D ends of  $Q1$  shall not be more than  $0.15\text{V}$  if  $Q4$  conduction is desired; hence,  $V_{be}$  voltage of  $Q4$  is  $0.6\text{V}$ .

Whenever the current output  $ID1$  from transformer 1 is varying in shape as shown in Fig.2; if current  $ID1$  is larger than  $1\text{A}$  then  $Q4$  cuts off and  $V_{gs}$  makes  $Q1$  conducts at full speed. If  $ID1$  is smaller than  $1\text{A}$ , then  $Q4$  will conduct and make the voltage drop over s-d ends of  $Q1$  to remain at  $0.15\text{V}$ . When current  $ID1$  is zero, resistance of  $Q1$  will be infinite large and makes  $Q1$  to automatically enter cut-off state.

In other words, the main function of the second control circuit 31 in this embodiment is to let resistance of second switching circuit 32 to vary along with output secondary current  $ID1$  and present an inverse proportional waveform. Hence, when secondary current  $ID1$  drops to zero the resistance of second switching circuit 32 will enter cut-off state due to  $Q1$  resistance becomes infinitely large.

However, in the second control circuit 31 in the above describing article, the  $Q1$  would only cut-off at the time when secondary current  $ID1$  reaches zero

value. In other words, flyback power supply is operating under non-continuous mode at this time. If one wish to make flyback type alternation power supply to work in continuous mode, then first control circuit 22 must send out cut-off control signal to second switching component 32.

5        The operation of continuous mode of the embodiment is described as following; please refer to waveforms in Fig.5. Similarly, we assume secondary current  $ID1$  has a reverse triangular waveform, first switching component 21 is in cut-off state and second component 32 is in conducting state. The control IC U1 controls conduction state (conducting or cut-off) of the first switching  
10    component 21 through its pin 6. Further, pin 4 of the control IC U1 outputs a saw tooth shape waveform for driving a buffer, which constitutes transistors Q7 and Q8. The butter further sends out signal to drive switching state variation of transformer T2. Moreover, frequency of mentioned saw tooth shape waveform can be adjusted by resistor  $R_T$  and capacitor  $C_T$ .

15        As shown in Fig.5, at the time  $T1$  the voltage at the pin 4 of control IC U1 starts to descend from 4V towards 1V and causes changes in switching state on secondary side of transformer T2. The transistor Q5 then enters conducting state from cut-off state. The voltage level of  $V_{ce3}$  and  $V_{ce4}$  transistor fall from high level to zero and causes resistance in Q1 to approach infinity for entering  
20    cut-off state. Hence, the secondary current  $ID1$  at the time  $T2$  will descend to zero ampere and pin 6 of control IC U1 sends out a signal for driving first switching component 21 to conduct. Further, before secondary current  $ID1$  descends to zero, it forces the second switching component 32 to enter cut-off state at time  $T2$  due to voltage level of transistors  $V_{ce3}$  and  $V_{ce4}$  has dropped

to zero level at time T1. Therefore, the flyback type alternation power supply could now be operated in continuous mode.

Please refer to Fig. 6: the circuit diagram of third embodiment in the present invention. Wherein, the control circuit 22 is constituted a by

5 pulse-width modulation IC U2 (number 6841), capacitors (C3,C4,C5), resistors (R7, R8, R9, R10, R11), diodes (D5, D6, D7), and transistors (Q9, Q10).

As shown is Fig.7, pin 8 of control IC U2 is an output controlling pin. Its voltage output does not immediately rise to Vcc, but rise along a slope from 0V to 5V then straight up to Vcc voltage. Therefore, Q6 starts to conduct when  
10 output voltage at pin 8 of IC U2 reaches 5V. This embodiment uses the period that pin 8 rises from 0V to 5V(about 800ns) before the transistor Q6 conducts to obtain synchronize pulse-wave signal for shutting downing transistor Q1. In this way, the situation of simultaneous conduction of Q1 and Q6 will be avoided.

15 When pin 8 of control IC U2 outputs 0V voltage, transistor Q10 does not conduct but transistor Q9 does, and capacitor C5 is charging. Because diode D5 is conducted and therefore the primary side of transformer T2 has a voltage of 0.6V. The secondary side of transformer has low voltage (zero) and transistor Q5 is switched off.

20 The next situation is when voltage at pin 8 of control IC U2 rises from 0V to 1V; at this time, transistor Q10 is conducted (Q10 must kind of FET that can be conducted at 1V). However, at this point in time the transistor Q6 has not yet conducted and due to the conduction of transistor Q10, the transistor Q9 is switched off and capacitor C5 will discharge. Because of discharging on

capacitor C5, the primary side of transformer T2 will generate a negative  $V_{cc}$  wave pulse ( $-V_{cc}$ ). Further, because of the reverse polar property at two sides of transformer, the secondary side of transformer T2 hence has positive wave signal for driving transistor to conduction. The conduction of transistor Q5  
5 leads to the turn-off of transistor Q1. The transistor Q6 will start to conduct when the output voltage at pin 8 of control IC U2 rises to about 5V. Until the pin 8 voltage of control IC U2 again drops from high (5V) to low (0V) voltage, then the transistor Q6 will switch off and transistor Q1 conducts.

According to the above article, by controlling the time of outputting  
10 cut-off signal from insulating unit 4 to second switching component 32 using first control circuit 22, the present invention can hence perform in continuous and non-continuous mode. Furthermore, it also ensures that both first switching component 21 and second switching component 32 will not conduct at the same time during switching state of transformer 1. This overcomes the  
15 drawback of burning second switching component 32 if the first switching component 21 and second switching component were to be switched on together. Wherein the non-continuous mode operation, the cut-off signal could be sent out by first control circuit 22 when secondary current  $ID1$  descends to zero. In other case, when the first switching circuit 22 did not send out a cut-off  
20 signal even if secondary current  $ID1$  drop to zero, the invention still use second control circuit 31 to control the resistance variation of second switching component 32. The resistance of second switching component 32 changes along with current outputted by transformer 1 and has an inverse proportional variation that makes second switching component 32 to enter cut-off state due

to infinite resistance.

Although the present invention has been described with reference to the preferred embodiment thereof, it will be understood that the invention is not limited to the details thereof. Various substitutions and modifications have  
5 suggested in the foregoing description, and other will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intending to be embraced within the scope of the invention as defined in the appended claims.

While the preferred embodiment of the invention has been illustrated and  
10 described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.